

SUMMARY OF RESEARCH

Human Dimensions of Deforestation and Regrowth in the Brazilian Amazon: Integrating Data from Satellites, Demographic Censuses, and Field Surveys

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1. Overview of Research Objectives and Activities

This report summarizes research activities and products from a collaborative project on the “Human Dimensions of Deforestation and Regrowth in the Brazilian Amazon,” awarded to Charles H. Wood (PI; Department of Sociology, University of Texas at Austin, now in the Center for Latin American Studies, University of Florida), Steven E. Sanderson (Co-PI; Department of Political Science, University of Florida, now Dean of Emory College, Emory University) and David L. Skole (Co-PI; Institute for Earth, Oceans and Space, University of New Hampshire, now in the Department of Geography and Basic Science Remote Sensing Initiative, Michigan State University).

The proposal presented the justification for three research objectives, jointly carried out by these investigators during the course of the project:

1. Use a GIS to integrate satellite data on land cover with demographic and agricultural census data on population and land use in order to model the socio-economic determinants of deforestation and regrowth in the municipalities of the Brazilian Amazon.
2. Develop a conceptual framework that specifies determinants of deforestation and regrowth at different spatial and temporal scales.
3. Apply the Brazil findings to the modeling objectives of the broader IBGP-HDP Land Use and Land Cover Change Core Project.

The remainder of this summary of research reviews activities and products toward these three research objectives.

2. Objective 1: Merging Satellite and Census Data

Through the course of the project, the team successfully merged satellite and sociodemographic and agricultural census data at the municipal level to construct two integrated data files for the entire Brazilian Amazon, each with data for a different time period.

Satellite-based land cover were derived via the NASA-funded UNH Pathfinder Project and the MSU BRSI. Estimates of land cover refer to Brazilian municipalities, and came from 1986 and 1992 Landsat TM images. Satellite scenes were reconfigured in a GIS from raster format to vectors that corresponded to municipal boundaries. Land cover indicators for each municipality at each time point include primary forest, deforestation, regrowth, cloud, cloud shadow, water and missing data.

Sociodemographic data came from two microdata files of Brazilian demographic censuses: a 25% household sample of the 1980 census and a 15% sample of the 1991

enumeration. Because questionnaire instruments for the two were virtually identical, the project team was able to derive comparable sociodemographic indicators at the municipal level for both census years. Indicators for both years included: population size (total, rural and urban), migrants (rural and urban), children born during the previous year (for fertility estimation), child survival (for mortality estimation), income and housing quality, and occupation (farmer, rancher, miner, day laborer, rubber tapper and others).

Agricultural census data came from municipio-level figures in published volumes of Brazil's 1980 agricultural census. Agricultural indicators include: number of rural establishments, size of rural establishments, land use (annual crops, perennial crops, pasture, fallow, forest, and others), credit and investment, agricultural labor, machine and chemical inputs, annual and perennial crop production, cattle herds and extracted forest products.

The satellite and census data were then merged in a GIS. One merged file contains census-based sociodemographic and agricultural indicators for 1980, and satellite-based land cover indicators for 1986, a total of 253 variables for 367 municipalities. The second merged file contains similar census-based indicators 1991 (demography) along with land cover variables for 1992, totaling 193 variables for 508 municipalities.

3. Objective 2: Developing a Conceptual Framework

Drawing on hierarchy theory, the team developed a conceptual framework to coherently organize the many proposed explanations for land cover change in the Amazon by situating them according to the spatial and temporal scales at which they operate. This allowed for distinctions to be made from more local and frequently occurring "proximate" determinants, as contrasted with somewhat more distant and less frequent "intermediate" factors, and yet more remote and less frequent "distant" determinants. Land cover most directly reflects land use decisions made by individuals, which in turn reflects household or firm needs, which reflects local community circumstances, which reflects regional development, national states, economies and populations, and international political and economic relations. Land cover also reflects proximate, intermediate and distance biophysical factors such as local soils, weather, and climate change, respectively. The framework also accounts for feedbacks from land cover outcomes to agents operating on larger scales, such as by species loss, soil erosion, health consequences or carbon emissions. The framework helps specify the processes operating on a given scale that theoretically should influence land cover when observed at that scale.

4. Objective 3: Modeling Land Cover

The team has encountered and surmounted several challenges in order to develop models of land cover for municipalities in the Brazilian Amazon. Initial OLS models indicated strong relationships and high proportions of variance explained (over 0.50), but regression diagnostics also indicated the presence of non-normality, heteroskedasticity, and spatial autocorrelation. The team opted for a ln-ln specification to eliminate non-

normality, but substantially more effort was required to address the other two estimation problems. To address heteroskedasticity, the team identified subregions of the Amazon as groups of municipalities with different histories, where relationships between sociodemographic and land cover variables will likely differ. The team enlisted the consulting of Luc Anselin, a spatial econometrician and creator of Spacestat. Anselin used Spacestat to draw on GIS-based information about spatial contiguity and distances among municipality centroids and administrative seats and specify regression models that account for the effects of spatial autocorrelation in order to obtain unbiased and efficient estimates of the coefficients.

5. Products from the Research Activities

The activities described above generated two integrated data files and models from each that use appropriate statistical techniques to specify the effects of sociodemographic variables on deforestation and other indicators of land cover in the Brazilian Amazon. The team has produced several papers, presentations and publications out of this work (see attached reference list).

The data files and models bear important implications for the IGBP-HDP Core LULCC Project because the methods used to generate these products are in principle applicable to any other part of the world for which similar data are available. A key focus of the IGBP-HDP Core Project is to derive methods for modeling the human dimensions of land use and land cover change in order that such models then be applied, for example, to global environmental modeling. The use of data from censuses and satellite images, their integration in a GIS, and submission to regressions with spatial econometric techniques are all replicable outside the Brazilian Amazon, and open the prospect for development of this as a protocol for human dimensions research on land cover.

That said, it is also important to recognize the limitations of this methodological approach. The data are limited with respect to their spatial and temporal resolution, in that municipalities are not standardized spatial units and censuses are not performed frequently. Moreover, interpretations of models based on aggregate data are limited to the correspondence of populations to areas under a certain land cover, rather than decisions or other behaviors engaged in by individuals. Hence, causal interpretations must be made with great care when reviewing the models produced.

The team has also experimented with spatio-temporal land cover models, by combining the two data sets and modeling the effects of changes in sociodemographic factors on changes in land cover. This presents additional methodological difficulties as municipal boundaries change over time, requiring reaggregation of units and the loss of cases and spatial resolution.

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